C-CORE

CENTRE FOR COLD OCEAN RESOURCES ENGINEERING
MEMORIAL UNIVERSITY OF NEWFOUNDLAND
ST. JOHN'S NEWFOUNDLAND A1B3X5 CANADA
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Annual Report 1985-86

C-CORE

ANNUAL REPORT

1985 - 1986

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C-CORE

Centre for Cold Ocean Resources Engineering

"A self-reliant organization of Memorial University". The purpose of C-CORE shall be to undertake engineering research designed to assist in the safe and orderly development and utlization of Canada's ocean-related resources.

C-CORE concentrates its research activities in a limited number of areas. Research topics include:

Ice

- Ice Dynamics
- Ice Mechanics
- Ice-Structure Interaction

Ground Wave Radar

- Ice Detection
- Surface Currents
- Wave Measurements

Seabed Geotechnics

- Geophysical Studies
- Geotechnical Analysis
- Hibernia Sediments
- Iceberg-Seabed Interaction

C-CORE was established in 1974 with a grant from the Devonian Group of Charitable Foundations.

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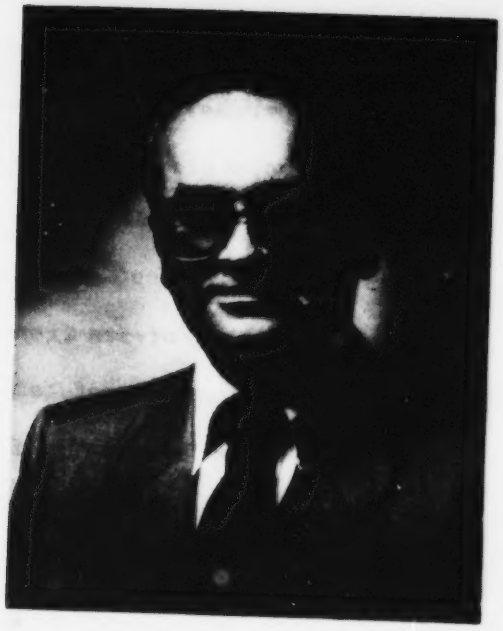

Dan R. Motyka

REPORT FROM THE CHAIRMAN OF THE BOARD OF GOVERNORS

In the past year, C-CORE has successfully faced many challenges and has demonstrated its ability to anticipate and to react quickly to new situations. Two major factors have affected C-CORE's research priorities and its existing funding mechanisms. With the decline in world oil prices, offshore exploration activity in Canada has decreased to a level not seen since the early seventies and the Federal Government is reviewing its priorities in order to propose new and effective ways to support research and development. The Board and management of C-CORE have monitored the impact of these events and have implemented measures to ensure the Centre remains sound and viable.

C-CORE has been able to maintain the research support from its Associates and attract new sources of funding. Increased contract funding in 1985 and 1986 is gratifying in that it reflects our ability to succeed in a highly competitive marketplace in times when acquiring funds for research is tough.

Regular communication between the Board of Governors, the Associates and the staff of C-CORE has produced a research program which is finely tuned to reflect today's priority areas of research. Success in implementing new research initiatives, undertaking cooperative programs and identifying new sources of funding demonstrates the continued viability of this Canadian research centre.

In 1986-87, as industry places many of its frontier programs on hold, C-CORE must make sure that industry and government recognize that investments in research today will yield tremendous benefits in future years. The Board of Governors, the Associates and the staff of C-CORE are totally committed to the concept of a research centre such as C-CORE that closely ties together the activities and interests of industry, governments and universities. We will work together during this year so that C-CORE will be able to respond to new initiatives in the future.

Dan R. Motyka

DIRECTOR'S REPORT

Cooperative Research: the C-CORE Model

The past year has been one of the most active in the history of C-CORE. The Centre's continued involvement in cooperative research programs with industry, government and university groups is an important and central component of our activities. This is demonstrated by the number of field programs we are involved in with other agencies or groups and by our ability to attract funding to support these activities from a number of sources.

A policy decision was made at the beginning of the year to strengthen the core research team with a number of senior staff. The objective was to improve our capability to attract support from various funding agencies and to increase the Centre's ability to undertake contract research for government and industry. Two senior staff from industry in the fields of ice mechanics and geophysics were appointed; two engineering faculty members were cross-appointed to C-CORE's research team for radar research and ice dynamics; and C-CORE staff were encouraged to upgrade their academic qualifications by undertaking further graduate studies. Increased support from the university granting council and substantial increases in contract support show how successful these measures have been.

During the 1985 summer field season, the staff level of C-CORE, including a number of part-time employees and summer student assistants, reached a peak of 52 people. Currently there are 33 full time employees of whom 22 are research staff. The total staff number has been scaled down in response to the reduction in offshore activity, but C-CORE has been able to upgrade its research capability and retain "critical mass" in priority areas of research.

Research priorities have undergone a major review during the year. In 1985, in consultation with industry and government, C-CORE implemented a five year research plan. The drastic cuts in industry since then, necessitated a review of this plan prior to the beginning of the 1986/87 fiscal year. Certain programs have been given priority and others have been placed on hold. The Centre will continue its research activity within the three main research areas of Ice, Remote Sensing and Seabed but will emphasize specific programs within these major areas.

Industry, government and university representatives discussed research directions and funding requirements at the March Board Meeting of C-FER and C-CORE. (Matthews Photo Lab Ltd., Calgary)

In the Ice Group the activity is directed to ice dynamics and ice mechanics. C-CORE was actively involved in the design and execution of the major field program, Dynamics of Iceberg Grounding and Scouring (DIGS), which drew industry, government and academia together to acquire unique data sets on icebergs grounding and scouring and the motion of small ice masses. The

analysis of ice-structure interaction data from the Beaufort Sea was carried out under a secondment arrangement to Gulf Canada Ltd. A cooperative R&D program is being formulated to continue this activity.

In the Remote Sensing Group, substantial industrial support has been given by Mobil Oil Canada, Ltd. and Petro-Canada Resources for the use of ground wave radar for ice detection. The objective of the program is to develop an operational capability for offshore surveillance. The radar team in the Faculty of Engineering and Applied Science is an active partner in this program. The oceanographic and current measurement program was carried out during a major government winter field program, the Canadian Atlantic Storms Program (CASP), in which many groups were involved.

In the Seabed Group collaborative programs are carried out with the Atlantic Geoscience Centre. The group was also involved in the DIGS experiment, gathering data on the iceberg grounding events. The geophysics program is developing a new technique for measuring seabed properties and bringing together groups from industry and government. The geotechnics program is carried out cooperatively with the Faculty of Engineering and Applied Science.

Research activities at C-CORE provide opportunities for graduate and undergraduate students to gain valuable work experience and training and to be involved in programs where project scheduling and budgets are key elements. Support of the graduate students in Engineering and Earth Sciences through the C-CORE Fellowship Program is just one example of how C-CORE achieves its educational training objective to provide a base of training in Newfoundland for young scientists and engineers.

C-CORE's program objectives have been achieved through a combination of strong financial support from our Associates, substantially increased research funding from the Natural Sciences and Engineering Research Council, project

funding and support-in-kind from both the provincial and federal governments and support-in-kind from Memorial University of Newfoundland and from industry. Access to vessels and submersibles, a supply of cores and geophysical data, secondments to and from Associates, logistic support for field programs, support for capital equipment purchases, provision of space and technical support, and access to laboratories are just some of the types of support-in-kind and cooperative research fostered by C-CORE with groups in industry, government and universities.

It is, however, the working relationships with members of the Associates from industry and government and with members of the university community and colleagues in other institutes that make C-CORE a success. The definition of the research plan and the continuing relevance of the Centre's work is achieved through these relationships. The willingness and ability to initiate and participate in cooperative research and development is a key factor in the growth of Canadian research. The current financial cutbacks in both industry and government have emphasized the importance of cooperative R&D to make the most effective use of available research dollars. An organization like C-CORE that is not government, not industry and not university but is in fact a bit of each is uniquely positioned to initiate and respond to significant cooperative research opportunities.

Jack I. Clark

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* Retired 1986 ** Joined 1986

C-CORE ASSOCIATES

Industries and government agencies contribute financial logistic support to the research programs of C-CORE. The Associates also provide invaluable technical direction and guidance to C-CORE's research programs.

At the annual Associates' Workshop and at regular meetings through the year, the research staff at C-CORE discuss proposed research programs with representatives from the Associates. Advice received is incorporated into the programs; cooperative programs with industry and government groups are also planned.

1986 ASSOCIATES OF C-CORE

Government

Energy, Mines and Resources Canada
Fisheries and Oceans Canada
National Research Council Canada
Transport Canada

Oil and Gas Industry

Bow Valley Industries
BP Canada Inc.
Canterra Energy Ltd.
Esso Resources Canada Limited
Gulf Canada Corporation
Husky Oil Operations Ltd.
Mobil Oil Canada Ltd.
Norcen Energy Resources Limited
Petro-Canada Resources
Shell Canada Resources Limited
Texaco Canada Resources Limited

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Bechtel Canada Limited
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CANPOLAR Consultants Ltd.
Det norske Veritas (Canada) Ltd.
Dobrocky Seatech Ltd.
Fenco Newfoundland Limited
GEOTECHnical resources ltd.
Golder Associates
INSTRUMAR Limited
Newfoundland Geosciences Ltd.
NORDCO Limited
NorTek Engineering Inc.
Royal Bank of Canada
ShawMont Newfoundland Limited
Viatec Resource Systems Inc.
Westinghouse Canada Inc.

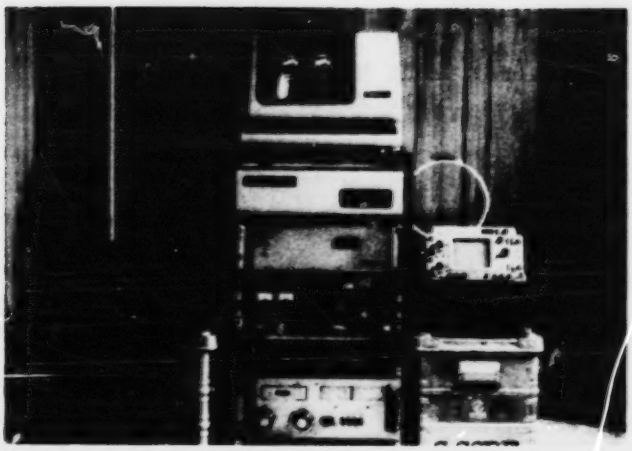
REMOTE SENSING

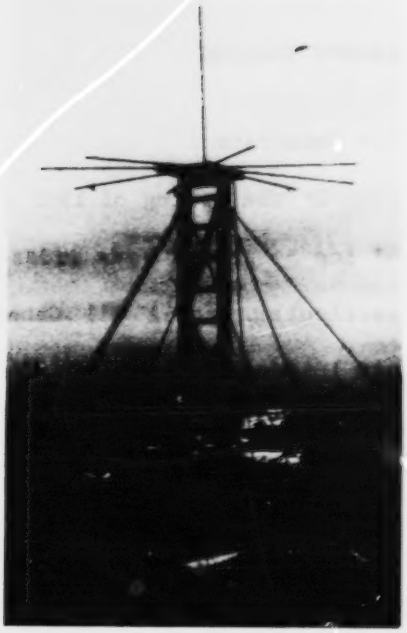
Leaders: Bill Winsor
John Walsh

Ice Detection

In the spring of 1985 a three phased program was started on the detection of ice by ground wave radar funded by the industrial Associates of C-CORE, in particular, Mobil Oil Canada Ltd. and Petro-Canada Resources. This research was initiated in 1982 in the Faculty of Engineering and Applied Science under a three year ocean strategic grant from the Natural Sciences and Engineering Research Council (NSERC). Work was undertaken cooperatively with the group at C-CORE.

The objective of the present program is to develop a rig-mounted ice sensor for operational use. The first phase of the program focused on the software and analytical techniques to improve the detection of icebergs in the presence of ocean clutter. The group has directed its attention to the specific application of a monostatic rig mounted ground wave radar for the detection of ice hazards. The report of Phase I recommended that analytical results be verified by an experimental program using ground wave radar. In the field data collection program, the experimental radar will be deployed on a small island or barge which will simulate an offshore rig to determine the accuracy of the analytical descriptions of environmental scattering and iceberg detection models. The field work is very closely tied to modification of the existing ground wave radar system (Coastal Ocean Dynamics Applications Radar, the CODAR system) for operation at a second frequency centred at 6 MHz in the HF band. This modification is required to foster the engineering developments which will be required for new offshore applications of ice surveillance and wave warnings. Funding for this modification is supported





Above: CODAR field equipment

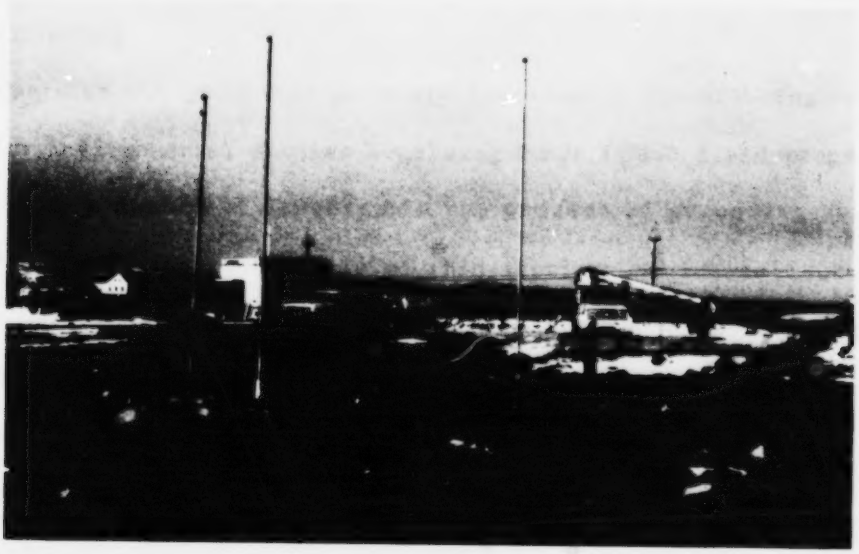
Right: One configuration of CODAR antenna tested at Cappahayden, Nfld. in preparation for CASP.

under an infrastructure grant from NSERC.

Oceanographic Remote Sensing

The members of the group were heavily involved in the Canadian Atlantic Storms Program (CASP), a joint research project of Fisheries and Oceans Canada and Environment Canada. CASP was conducted to study the processes and conditions which cause severe winter storms in the North Atlantic ocean and thus improve the ability to forecast these events. Most of the Remote Sensing group were in Nova Scotia for the winter months undertaking surface current measurements during storms, from two coastal sites. The surface current data was provided to the Atlantic Oceanographic Laboratory at the Bedford Institute of Oceanography in the form of radial current maps and combined surface current vector maps. These data sets form only part of the total experimental data collected in a wide range of ocean and weather studies by other groups using the CASP experiment.

Involvement in CASP gave the Memorial University team an opportunity to collect dependable datasets on ocean conditions to use in its ongoing research on ocean waves. The team, comprising researchers from the Faculty of Engineering, C-CORE, the Department of Mathematics and Dr. Perrie from the Atlantic Oceanographic Laboratory, was awarded a three year NSERC ocean strategic grant in the fall of 1985 to investigate the use of ground wave radars for ocean wave measurements.



Preparing the site at Seaforth, Nova Scotia. CODAR transmit antenna is seen in the foreground.

SEABED

Leaders: Vaughn Barrie
Jacques Guigne

Hibernia Sediments

The Hibernia program included two field site visits on the Canadian Forces vessel, **HMCS CORMORANT** in the **SDL-1** submersible and on the Department of Fisheries and Oceans vessel, the **PANDORA II**, in the **PISCES IV** submersible. From the submersibles it was possible to examine iceberg scour pits, to undertake an investigation of the B-08 glory hole and to establish three sediment transport sites.

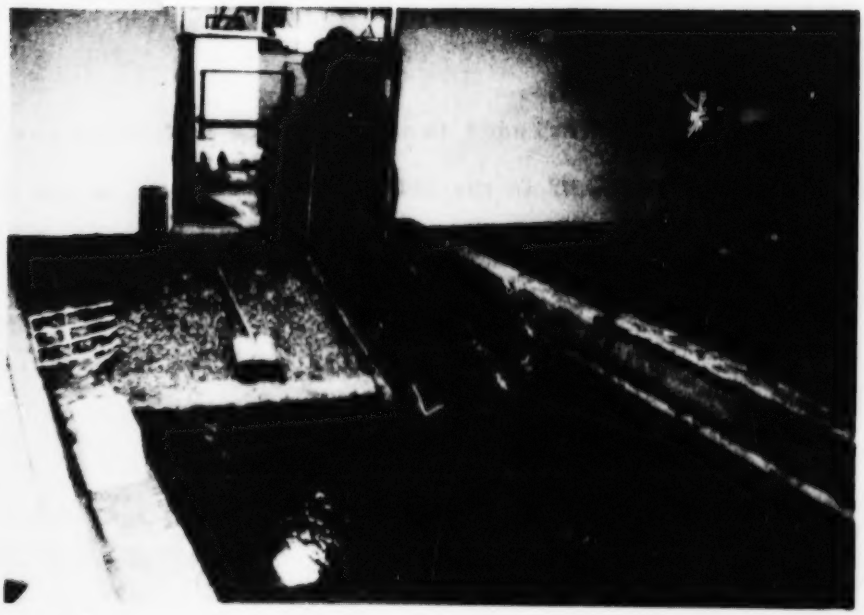
Iceberg Scouring

Members of the group were actively involved in the planning and execution of a major Environmental Studies Revolving Funds (ESRF) field program. During the project, a number of icebergs in the process of grounding were closely monitored. Petrographic analysis of thin sections of ice collected from the keel of one of the grounded bergs indicated that an impressive amount of seabed sediment had been forced into the keel ice during the grounding event. Examination of two recent scours provided new insights into the actual mechanisms and processes of scouring.

The technical work on the ESRF study on upslope and downslope iceberg scouring was completed. This report will provide a database on upslope and downslope ice scour statistics for analysis and modelling.

Geotechnical Studies

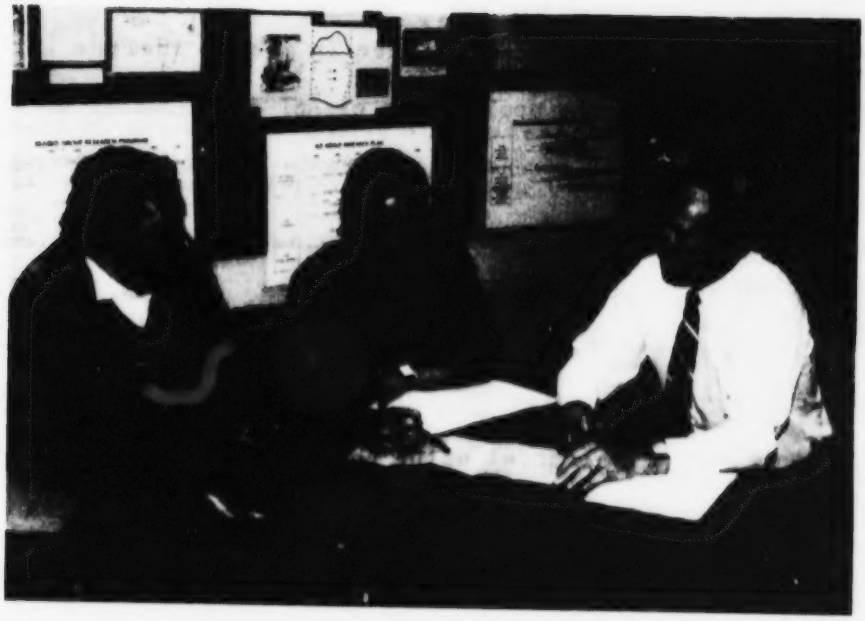
Funding provided by NSERC was directed towards soil-structure interaction studies of bottom founded structures and post grounding behaviour of icebergs subjected to intense wave loading. The work involves laboratory studies and field programs. A graduate student in Engineering is also working on the project as part of his M.Eng. degree.



The test soil for the soil-structure interaction research project was deposited in the wave-soil-scour tank as a slurry to ensure saturated soil conditions similar to those found on the ocean bottom.

An NSERC infrastructure grant was awarded to C-CORE and the Faculty of Engineering and Applied Science in support of geotechnical testing capability. A geotechnical technician has been hired who is skilled in the maintenance and operation of the equipment for geotechnical-geological testing.

Members of the C-CORE staff were actively involved in the organization of the Third Canadian Conference on Marine Geotechnical Engineering which was held in St. John's. Over a hundred delegates attended the three day conference. The sessions included presentations on the East Coast and Beaufort Sea activities. The Newfoundland Department of Development and Tourism, the Ocean Industries Development Centre (DRIE) and NSERC provided financial support for the conference.



Members of the Organizing Committee discussing the program for the Third Canadian Conference on Marine Geotechnical Engineering

Geophysical/Geotechnical Program

In June of 1985, the geophysical program at C-CORE was initiated. Using an acoustic technique known as the Acoustic Sub-seabed Interrogator (ASI), the summer program concentrated on the experimental verification of the ASI's theoretical models. The objective of the research is to take detailed acoustic/geotechnical measurements of sedimentary structures using ASI to enable the physical and elastic properties of the soil to be obtained from acoustic responses.

Work by the group during this year also concentrated on planning the three year program for the ASI development and securing funding from a number of agencies and industries. Funding for the program has been obtained from the National Research Council's Industrial Research Assistance Program, the Department of Energy, Mines and Resources, the Ocean Industries Development

Centre of the Department of Regional Industrial Expansion (DRIE) and the granting council, NSERC. Major activities in 1986/8 include laboratory studies, field programs and the application of ASI for a number of different concepts such as monitoring of stress and strain in offshore structures.

Other Seabed Activities

The geological members of the group undertook a number of other programs which included analysis of cores collected in the Flemish Pass and the development of an analytical model using the sediment transport theory to determine areas likely to be heavy in mineral concentrations. These programs have been placed on hold as the Centre moves into 1986-87 because of the economic problems being experienced by the oil industry.

Ice Leaders: Dr. Jim Lever
Dr. Jean-Paul Nadreau

Ice Dynamics

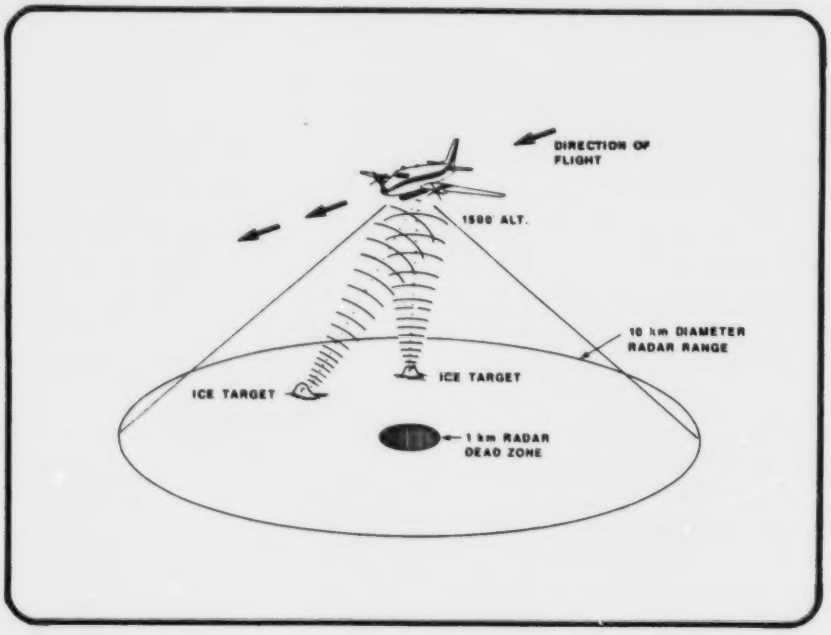
Members of the Ice Group made a significant contribution to the design and execution of the ESRF Dynamic Iceberg Grounding and Scouring (DIGS) experiment. This group provided two motion sensor packages for monitoring the iceberg motion component of the grounding events. In return, logistic support was provided to the Centre's scientists to collect field data on the wave-induced motion of small icebergs, bergy bits and growlers for the NSERC supported program. These data have been used to validate the theoretical and experimental models. The group is also involved in the analysis of the full scale data collected on three iceberg/seabed interactions for ESRF.

Placing a motion sensor package on an iceberg during the DIGS program.

A model to handle three dimensional irregularly shaped icebergs has been developed at the Faculty of Engineering and C-CORE. The model has been used

to investigate the degree of accuracy with which the outline of an iceberg must be measured in order to predict correctly whether an iceberg will roll when being towed by a supply vessel. Observations made during the summer field program on iceberg splitting has initiated an investigation on the influence of splitting on an iceberg population using a statistical model.

The group also began work on the evaluation of two maritime search radar systems for the detection of ice, an ESRF supported study.



The geometry of search radar produces a circular swath centred below the aircraft. Targets within this area are scanned approximately every two seconds.

Ice Mechanics

A new program in ice mechanics and ice/structure interaction research was started at C-CORE in 1985. A preliminary analysis on the dynamic behaviour of Gulf Canada's Mobile Arctic Caisson (MAC) was completed for the company. The purpose of the study is to analyse the response of the structure when it is subjected to ice forces.

Planning was also undertaken for an NSERC funded program on the tridimensional state and failure of ice. The initial part of the program is aimed at basic research on ice properties studying the effects of multiaxial stress states on ice strength and deformation.

Labrador Ice Margin Experiment (LIMEX)

An experimental framework for an ice margin experiment on the Grand Banks has been defined. A series of integrated programs have been proposed which include remote sensing and ground-truthing activities. Input for the experiment was received from industry, government and university groups. Technical direction was provided by Dr. Peter Wadhams of the Scott Polar Research Institute. A revised plan for LIMEX has been prepared. It is proposed that the experiment will take place in March of 1987. Logistic support of the project has been identified and the Centre is now in the process of raising financial support for the project.

INFORMATION

CANADIAN SEA ICE INFORMATION SYSTEM (CSIIS)

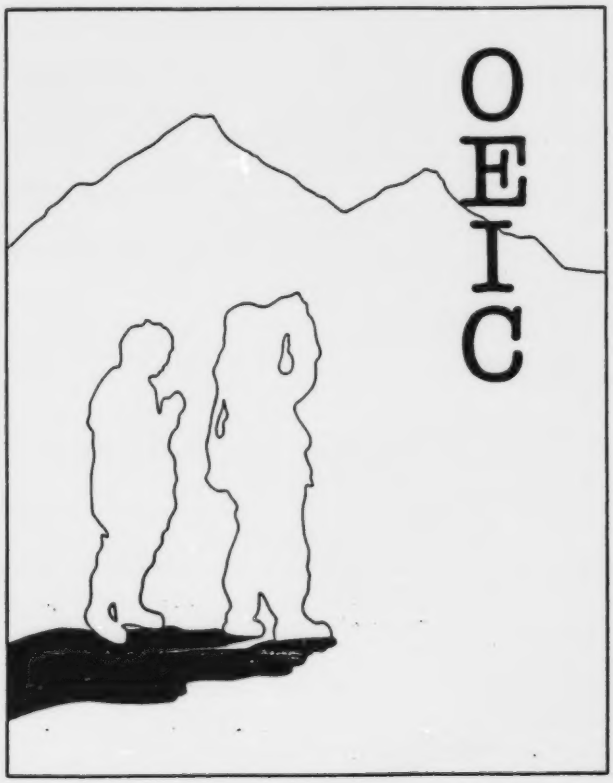
Work on this program has concentrated on data entry and testing to ensure reliable performance. Several C-CORE Associates were invited to participate in an evaluation of the system. When the evaluations were received, the Centre made a number of changes to the system and identified a number of priority areas which should be addressed in the system's future development.

A marketing strategy has been developed with support from the Newfoundland Department of Development and Tourism. The U.S. Department of Energy, currently in the process of developing a computer system to handle ice and seabed information, has expressed great interest in using the CSIIS format as its standard.

OCEAN ENGINEERING INFORMATION CENTRE (OEIC)

OEIC was awarded a contract from the Department of Fisheries and Oceans to determine whether the collection of OEIC could be used as an information resource for Canadian ocean technology documents for Aquatic Sciences and Fisheries Abstracts. Work continued on the transfer of cold ocean information onto the Arctic Sciences and Technology Information System database supported by funds from ESRF. Priority topics were ice scouring and icebergs.

The Ocean Engineering Information Centre prepares a current awareness bulletin which identifies recent technical literature from many sources. Topics covered include cold ocean engineering, sea ice research and environmental data related to Canadian northern waters. Information on upcoming conferences and workshops is also included. The Bulletin, is available on an annual subscription basis.



REPORTS AND PUBLICATIONS FOR 1985

85-1 Stander, E. "The Measurement and Analysis of Strainmeter Data from Adams Island, Navy Board Inlet, N.W.T.". Contract report for National Research Council of Canada, C-CORE Technical Report, April 1985, 34 p.

85-2 Diemand, D. "Iceberg Fragmentation by Thermal Shock". Iceberg Research, No. 8, October 1984, pp. 8-10.

85-3 Pereira, C.P.G. and Gillespie, R.T. "Davis Strait: Marine Geology, Sedimentology and Iceberg Scouring Analysis - Final Report". C-CORE Technical Report, June 1985, 46 p.

85-4 Winsor, W.D., Shirasawa, K., Hickey, K.J., Arscott, D.G., and Hay, A.E. "HF Radar Remote Sensing of the Surface Currents in the Strait of Belle Isle". Proceedings of the Ninth Canadian Symposium on Remote Sensing, St. John's, Nfld., August 14-17, 1984, pp. 203-212.

85-5 Donnelly, R., Jeans, P.K. and Arscott, D.G. "Applications of Spectral and Bearing Estimation Techniques to a Four Element Array used to Measure Ocean Currents". Proceedings of the Ninth Canadian Symposium on Remote Sensing, St. John's, Nfld., August 14-17, 1984, pp. 213-223.

85-6 Gillespie, R.T. and Rendell, C.M. "Centre for Cold Ocean Resources Engineering Sedimentation Tube: User Manual". Technical Report, May 1985, 41 p.

85-7 Barrie, J.V., Collins, W.T. and Segall, M.P. "Holocene Development and Sediment Transport on the Northeastern Grand Banks of Newfoundland". Geological Survey of Canada, Open File 1396, 168 p.

85-8 Gilbert, G.R. and Barrie, J.V. "Provenance and Sedimentology Processes of Ice Scoured Surficial Sediments, Labrador Shelf". Canadian Journal of Earth Sciences, Vol. 22, No. 7, 1985, pp. 1066-1079.

85-9 Segall, M.P., Barrie, J.V., Lewis, C.F.M. and Maher, M.L.J. "Clay Minerals across the Tertiary Boundary Northeastern Grand Banks of Newfoundland: Preliminary Results". Current Research, Part B, Geological Survey of Canada, Paper 85-1B, pp. 63-68, 1985.

85-10 Pereira, C.P.G., Piper, D.J.W. and Shor, A.N. "Sea MARC 1 Midrange Sidescan Sonar Survey of Flemish Pass, East of the Grand Banks of Newfoundland". Contract report, Geological Survey of Canada, Open File 1161, available for viewing at all GSC libraries. Copies may be bought from Norman Wade Co. Ltd., 5426 Portland Place, Halifax, NS, B3K 1A1.

85-11 Woodworth-Lynas, C.M.T., Day, T., Cristian, D. and Seidel, M. "Surveying and Trenching an Iceberg Scour, King William Island, Arctic Canada". Iceberg Research, No. 10, April 1985, pp. 1-8.

85-12 Collins, W.T. and Barrie, J.V. "Preliminary submersible observations of an iceberg pockmark on the Grand Banks of Newfoundland". Iceberg Research, No. 10, April 1985, pp. 24-27.

85-13 Lever, J.H. and Diemand, D. "Measurement of Instantaneous Motions of Ice Masses at Sea: 1984 Pilot Program". Proceedings of the 8th International Conference on Port and Ocean Engineering Under Arctic Conditions (POAC '85), Narssarssuaq, Greenland, September-13, 1985, Vol. 2, pp. 988-997.

85-14 Woodworth-Lynas, C.M.T. and Barrie, J.V. "Iceberg Scouring Frequencies and Scour Degradation on Canada's Eastern Shelf Areas using Sidescan Mosaic Remapping Techniques". Proceedings of the 8th International Conference on Port and Ocean Engineering Under Arctic Conditions (POAC '85), Narssarssuaq, Greenland, September 6-13, 1985, Vol. 1, pp. 419-442.

85-15 Dawe, C.R. and Chari, T.R. "Dynamic Effects of Waves on Seabed Stability". Proceedings of Canadian Coastal Conference 1985, St. John's, Nfld., August 13-16, 1985, pp. 177-187.

85-16 Walsh, J., Dawe, B.J. and Srivastava, S.K. "A New Iceberg Detection System: Groundwave Doppler Radar". Proceedings of IEEE Electronicom '85, Toronto, October 7-9, 1985, Vol. 1 of 3, Paper 85094, pp. 220-222.

INFORMATION PUBLICATIONS

85-A "C-CORE News, Vol. 10, No. 1", March 1985, 8 p.

85-B "C-CORE News, Vol. 10, No. 2", July 1985, 8 p.

85-C Jeans, P.K. and Donnelly, R. "Four-Element CODAR Beamforming" (Abstract). Proceedings of the 1985 North American Radio Science Meeting, University of British Columbia, Vancouver, B.C., June 17-21, 1985, p. 603.

85-D Walsh, J., Srivastava, S.K. and Dawe, B.J. "Remote Sensing of Icebergs by HF Groundwave Doppler Radar" (Abstract). Proceedings of the 1985 North American Radio Science Meeting, Univeristy of British Columbia, Vancouver, B.C., June 17-21, 1985, p. 613.

85-E to 85-I In: Program with Abstracts, Annual Spring Meeting, Geological Association of Canada, Newfoundland Section, Memorial University of Newfoundland, St. John's, March 28 and 29, 1985.

85-E Barrie, J.V. and Lewis, C.F.M. "Sedimentological Conditions in the Hibernia Area: Constraints to Seabed Development" (Abstract).

85-F Clark, J.I. "Geotechnical Engineering Considerations in Resource Development " (Abstract).

85-G Pereira, C.P.G. "Marine Geology Studies of Constraints to Hydrocarbon Resource Exploration - Southeast Baffin Island Continental Margin" (Abstract).

85-H Segall, M.P., Lewis, C.F.M., Maher, M.L.J. and Barrie, J.V. "Clay Minerals Across the Tertiary-Holocene Boundary, Northeastern Grand Banks of Newfoundland: Preliminary Results" (Abstract).

85-I Woodworth-Lynas, C.M.T. " A Mechanism for Iceberg Scouring: Geological Process and Engineering Hazard" (Abstract).

85-J "C-CORE News, Vol. 10, No. 3", November 1985, 8 p.

REPORTS AND PUBLICATIONS FOR 1986

86-1 Klein, K. and Butt, A. "Improving the Display of Marine Radar Returns from First Year Sea Ice". Technical Report, March 1986, 75 p.

86-2 Emory-Moore, M. "Textural and Mineralogical Characteristics of Nearshore Sediments, Eastern Baffin Island". Data Report, March 1986, 55 p.

86-3 Walsh, J., Dawe, B.J. and Srivastava, S.K. "Remote Sensing of Icebergs by Ground Wave Doppler Radar". IEEE Journal of Oceanic Engineering, April 1986, Vol. OE-11, No. 2, pp. 276-284.

86-4 Diemand, D. and Lever, J.H. "Iceberg Splitting and its Implications for Deterioration Modelling". Proceedings of Canadian East Coast Workshop on Sea Ice, Bedford Institute of Oceanography, Dartmouth, Jan. 7-9, 1986. Canadian Technical Report of Hydrography and Ocean Sciences, No. 73, pp. 429-440.

86-5 Pereira, C.P.G. "Kyle FP-1 Wellsite Survey: Sedimentological Analysis". Contract Report for McElhanney Services Ltd., 56p.

86-6 Macko, S.J., Segall, M.P. and Pereira, C.P.G. "Geochemical and Mineralogical Studies in the Arctic Archipelago". Contract Report for Geological Survey of Canada Open File No. 1315, 1986, 28 p.

86-7 Lever, J.H. and Sen, D. "A Method to Upgrade Iceberg Velocity Statistics to Include Wave-Induced Motion". Proceedings of 5th International Offshore Mechanics and Arctic Engineering (OMAE) Symposium, Tokyo, April 14-18, 1986, Vol. IV, pp. 320-327.

86-8 Barrie, J.V., Collins, W.T., Clark, J.I., Lewis, C.F.M. and Parrott, D.R. "Submersible Observations and Origin of an Iceberg Pit on the Grand Banks of Newfoundland". Current Research, Part A, Geological Survey of Canada, Paper 86-1A, pp. 251-258.

86-9 Fader, G.B., Lewis, C.F.M., Barrie, J.V., Parrott, D.R., Collins, W.T., Miller, R.O. and d'Appollonia, S. "Quaternary Geology of the Hibernia Area of Northeast Grand Bank, Map 149680QG". Geological Survey of Canada, Open File No.1222, 1986.

86-10 Shirasawa, K. "The Effect of Water Drag and Ocean Currents on Ice Displacement at Adams Island, N.W.T., Winter 1984/85". Part I of a Contract Report for the National Research Council of Canada (Part II: 86-11) December 1985, 34 p. (Released, (01-26-1987).

86-11 Stander, E. "The Measurement and Analysis of Strainmeter Data from Adams Island, November 1984 to January 1985". Part II of a Contract Report for the National Research Council of Canada (Part I: 86-10) March 1986, 20 p. (Released, 01-26-1987).

86-12 Jeans, P.K. and Donnelly, R. "Four-Element CODAR Beam Forming". IEEE Journal of Oceanic Engineering, Vol. OE-11, No. 2, April 1986, pp. 296-303.

86-13 Dawe, B.J. "Noise Response Analysis of the CODAR HF Radar Receiver". Contract Report for Bedford Institute of Oceanography, May 1986.

86-14 Morin, P. and Dawe, C.R. "Geotechnical Properties of Two Deep Sea Marine Soils from Labrador Sea Area". Preprint, Third Canadian Conference on Marine Geotechnical Engineering at Memorial University, June 11-13, Vol. 1, pp. 117-137.

86-15 Clark, J.I., Landva, J., Collins, W.T. and Barrie, J.V. "The Geotechnical Aspects of Seabed Pits in the Grand Banks Area". Preprint, Third Canadian Conference on Marine Geotechnical Engineering at Memorial University, June 11-13, 1986, Vol. II, pp. 431-455.

86-16 Nadreau, J.P., and Michel, B. "Yield and Failure Envelope for Ice Under Multiaxial Compressive Stresses". Cold Regions Science and Technology, Vol. 13, No. 1, 1986, pp. 75-82.

86-17 Nadreau, J.P. and Michel, B. "Yield Envelope for Confined Ice". Ice Technology, T.K.S. Murthy, J.J. Connor, C.A. Brebbia, eds., Proceedings of the 1st International Conference, Cambridge, Mass., U.S.A., June 1986. Springer-Verlag, New York, pp. 25-36.

86-18 Nadreau, J.P. "Evaluation of the Ice Mechanism Involved in the Behaviour of the Single Point Ice Anchor". Contract Report for Mobil Oil Canada, Ltd.

86-19 Nadreau, J.P. "Dynamic Behaviour of the Molikpaq: Preliminary Analysis". Contract Report for Gulf Canada Corp.

86-20 Dawe, B.J., Jeans, P.K., Walsh, J. and Winsor, W.D. "Ice Hazard Detection with Ground Wave Radar". C-CORE Technical Report, October 1986, 84p.

86-21 Whittick, J.A. and Guy, E.V. "Canadian Sea Ice Information System (CSIIS): An Online Computer Database for Sea Ice and Iceberg Data". Proceedings of the Eleventh Northern Libraries Colloquy, Lulea, Sweden, June 9-12, 1986, pp. 119-124.

86-22 Diemand, D. and Lever, J.H. "Iceberg Stress State". Iceberg Research No. 12, 1986.

86-23 Chari, T.R. and Barrie, J.V. "Ice Scour Surveys, Statistics and Forces". Proceedings of IAHR Symposium on Ice 1986, Iowa City, Iowa, Aug. 18-22, 1986, Vol. II, pp. 385-404.

86-24 Barrie, J.V. and Luternauer, J.L. "Titaniferous Placers on the Central Continental Shelf of Western Canada". Current Research Part B, Geological Survey of Canada, Paper 86-1B, 1986, pp. 849-852.

86-25 Nadreau, J.P. and Michel, B. "Secondary Creep in Confined Ice Samples". Proceedings of IAHR Symposium on Ice 1986, Iowa City, Iowa, Aug. 18-22, 1986, Vol. 1, pp. 307-318.

86-26 Nadreau, J.P. and Michel, B. "Courbe intrinseque de la Glace en compression". Symposium on Physics and Chemistry of Ice. Grenoble, France, Sept. 1-5, 1986, in press.

86-27 Shields, D.H., Ladanyi, B., Murat, J.R. and Clark, J.I. "Stresses in Icebergs - Will the Pressuremeter Work?". In Situ Testing and Field Behaviour, Proceedings of 39th Canadian Geotechnical Society Conference, Montreal, P.Q., Aug. 1986, pp. 159-166.

86-28 Clark, J.I. and Landva, J. "The Controlling Factors of Ice Created Seabed Features Related to Production Systems in Canadian Cold Oceans". Proceedings PolarTech-86 (October), Espoo, Finland, Vol. 2, pp. 565-583.

86-29 Lever, J.H., Klein, K. and Diemand, D. "Design, Development and Deployment of Instrument Packages to Monitor the Motion of Glacial Ice Masses at Sea". Ice Technology, T.K.S. Murthy, J.J. Connor, C.A. Brebbia, eds. Proceedings of the 1st International Conference, Cambridge, Mass., U.S.A., June 1986. Springer-Verlag, New York, pp. 225-236.

INFORMATION PUBLICATIONS

86-A C-CORE News, Vol. 11, No. 1, March 1986, 8p.

86-B Josenhans, H.W., Barrie, J.V., Woodworth-Lynas, C.M.T. and Parrott, D.R. "DIGS '85: Dynamics of Iceberg Grounding and Scouring: Observations of Iceberg Scour Marks by Manned Submersible" Abstract. 14th Arctic Workshop: Arctic Land-Sea Interaction, Bedford Institute of Oceanography, Dartmouth, N.S., Nov. 6-8, 1985, p. 92.

86-C Segall, M.P. and Christian, A.D. "Seabed Investigations on Newfoundland's Continental Shelf". Newfoundland Journal of Geological Education, Vol. 9, No. 1, January 1986, pp. 41-48.

86-D Clark, J.I. and LeDrew, B.R. "A Survey of Newfoundland Capability to Conduct Research and Development on Rig Evacuation". Contract Report for The Department of Development and Tourism, Government of Newfoundland and Labrador, January 1986.

86-E C-CORE News, Vol. 11, No. 2, July 1986, 8p.

86-F Woodworth-Lynas, C.M.T. "Evidence of Partially Grounded Pleistocene Ice Sheet in the Hudson Strait". Newfoundland and Labrador Quaternary Association (NLQUA) Newsletter 7, July 1986.

86-G C-CORE News, Vol. 11, No. 3, November 1986, 8p.

DEPARTMENT OF THE AUDITOR GENERAL
ST. JOHN'S, NEWFOUNDLAND

AUDITOR'S REPORT

The Board of Regents
Memorial University of Newfoundland
St. John's, Newfoundland

I have examined the balance sheet of the Centre for Cold Ocean Resources Engineering as at 31 March 1986 and the statements of revenue, expenditure and surplus (deficit) and changes in financial position for the year then ended. My examination was made in accordance with generally accepted auditing standards, and accordingly included such tests and other procedures as I considered necessary in the circumstances.

In my opinion, these financial statements present fairly the financial position of the Centre as at 31 March 1986 and the results of its operations and the changes in financial position for the year then ended in accordance with accounting principles described in Note 1 to the financial statements applied on a basis consistent with that of the preceding year.

J.F. McGrath, C.A.
Auditor General

St. John's, Newfoundland
6 October 1986, except as to Note 7
which is as of 12 February 1987

CENTRE FOR COLD OCEAN RESOURCES ENGINEERING

BALANCE SHEET

AS AT 31 MARCH 1986

		1986		1985
ASSETS				
Current assets				
Research trust (Note 3)		$ 939,020		$1,243,147
Accounts receivable				
Operating	$ 102,530		$199,978	
Other	-		383,336	
	102,530		583,314	
Less: Allowance for doubtful accounts	-	102,530	3,874	579,440
Total current assets		1,041,550		1,822,587
Fixed assets - at cost				
Bartlett Building (Note 4)		1,038,841		1,038,841
Equipment (Note 5)	1,249,753		1,133,386	
Less: Accumulated depreciation	834,435	415,318	659,649	473,737
Total fixed assets		1,454,159		1,512,578
Total assets		$2,495,709		$3,335,165

	1986	1985
LIABILITIES AND EQUITY		
Current liabilities		
Accounts payable		
Operating	$ 30,377	$ 50,511
Current portion of deferred revenue	76,667	76,667
Due to Memorial University of Newfoundland	-	383,336
Current portion of interest-free demand loan from Memorial University of Newfoundland	52,170	-
Total current liabilities	159,214	510,514
Long-term liabilities		
Interest-free demand loan from Memorial University of Newfoundland (Note 7)	265,598	265,598
Deferred revenue	153,335	230,002
Total long-term liabilities	418,933	495,600
Total liabilities	578,147	1,006,114
Equity		
Equity in research trust	939,020	1,243,147
Equity in building	1,038,841	1,038,841
Surplus (deficit)	(60,299)	47,063
Total equity	1,917,562	2,329,051
Total liabilities and equity	$2,495,709	$3,335,165

See accompanying notes

Signed on behalf of Memorial University of Newfoundland

Chairman of the Board of Governors

Comptroller of Memorial University of Newfoundland

STATEMENT 2

CENTRE FOR COLD OCEAN RESOURCES ENGINEERING

STATEMENT OF REVENUE, EXPENDITURE AND SURPLUS (DEFICIT)

FOR THE YEAR ENDED 31 MARCH 1986

	1986	1985
REVENUE		
Research trust drawdowns	$ 948,000	$ 990,717
Research contracts	767,854	557,167
Other	18,214	31,126
Total revenue	1,734,068	1,579,010
EXPENDITURE		
Staff salaries	1,157,458	856,668
Research programs	388,196	449,866
Support services	123,493	138,339
Ocean Engineering Information Centre	76,989	82,209
Fellowships and training	75,781	22,203
Board of Governors	19,513	17,038
Total expenditure	1,841,430	1,566,323
Surplus (deficit) for the year	(107,362)	12,687
Surplus - beginning of year	47,063	34,376
Surplus (deficit) - end of year	$ (60,299)	$ 47,063

See accompanying notes

STATEMENT 3

CENTRE FOR COLD OCEAN RESOURCES ENGINEERING

STATEMENT OF CHANGES IN FINANCIAL POSITION

FOR THE YEAR ENDED 31 MARCH 1986

	1986	1985
Sources of working capital		
From operations		
Surplus (deficit)	$ (107,362)	$ 12,687
Add: Item not affecting working capital		
Depreciation	174,786	165,419
Total sources from operations	67,424	178,106
Increase in interest-free demand loan	52,170	-
Net trust contribution (Reduction) (Note 3)	(304,127)	155,447
Deferred revenue	-	230,002
Total working capital provided	(184,533)	563,555
Application of working capital		
Repayment of interest-free demand loan	-	50,000
Deferred revenue decrease	76,667	-
Purchase of fixed assets	116,367	440,662
Total working capital applied	193,034	490,662
Increase (Decrease) in working capital	(377,567)	72,893
Working capital - beginning of year	1,312,073	1,239,180
Working capital - end of year	$ 934,506	$1,312,073

See accompanying notes

CENTRE FOR COLD OCEAN RESOURCES ENGINEERING

NOTES TO FINANCIAL STATEMENTS

FOR THE YEAR ENDED 31 MARCH 1986

1. Accounting policies

(a) Basis of accounting

C-CORE follows the accrual basis of accounting except that contributions to C-CORE's research programs are deposited for credit to the C-CORE Research Trust, which is shown on a cash basis (Note 3).

(b) Depreciation

Depreciation is not recorded on the Bartlett Building (Note 4), however depreciation on other fixed assets is calculated on a straight line basis as follows:

Equipment	5 years
Tools and marine equipment	2 years
Computer software and other equipment	1 year

(c) Support-in-kind

Various services have been provided to C-CORE by Memorial University of Newfoundland and other agencies, without charge, and have not been included in these financial statements (Note 6).

2. Relation to Memorial University of Newfoundland

The Centre for Cold Ocean Resources Engineering (C-CORE) is a self-reliant organization of Memorial University which is owner of C-CORE's building and equipment and beneficiary of its assets and liabilities. In the event that C-CORE is terminated, facilities and equipment provided or acquired for C-CORE shall remain the absolute property of the University.

As such, these financial statement figures represent a segment of the activities of Memorial University of Newfoundland and are included in the audited financial statements of the University for the year ended 31 March 1986.

CENTRE FOR COLD OCEAN RESOURCES ENGINEERING

NOTES TO FINANCIAL STATEMENTS

FOR THE YEAR ENDED 31 MARCH 1986

3. Funds in Research Trust

The Comptroller of Memorial University of Newfoundland administers the C-CORE Research Trust on behalf of the Trustee, the Board of Regents of Memorial University.

Cash transactions in the Research Trust during the year were as follows:

Balance in bank, 1 April 1985	$1,243,147
Receipts:	
Industry	434,700
Government of Canada	119,560
Investment income	89,613
	643,873
Less: Transferred to the Centre's operations	948,000
Net reduction during the year	304,127
Balance in bank, 31 March 1986	$ 939,020

4. Bartlett Building

In order to properly reflect the entire operations of C-CORE as a separate entity, the Bartlett Building, which is owned by Memorial University of Newfoundland but of which C-CORE has exclusive use, has been included in the financial statements for 1986 and 1985 at a cost of $1,038,841.

5. Equipment

C-Core accounts for its equipment in three main categories, as outlined in Note 1.

Category	Acquisitions	Accumulated Depreciation	Net Book Value 1986	Net Book Value 1985
Equipment	$1,138,000	$723,763	$414,237	$473,737
Tools and marine equipment	91,941	90,860	1,081	-
Computer software and other equipment	19,812	19,812	-	-
	$1,249,753	$834,435	$415,318	$473,737

CENTRE FOR COLD OCEAN RESOURCES ENGINEERING

NOTES TO FINANCIAL STATEMENTS

FOR THE YEAR ENDED 31 MARCH 1986

5. Equipment (Cont'd)

C-CORE's equipment includes a VAX 785 computer and accessories. The Province of Newfoundland contributed $191,668 towards the cost of this computer and they have secured their contribution by way of a chattel mortgage dated 23 May 1985, which is being forgiven by the Province at a rate of 25% per year.

The Government of Canada also contributed $191,668 towards the cost of this computer. Terms of this contracted contribution require C-CORE to provide for the implementation and provision of a Sea Ice Data Base Service over the period from 22 January 1985 to 31 March 1989.

6. Support-in-kind

Management has estimated the cost of various services provided without charge by Memorial University of Newfoundland and other agencies at $2,270,100 for the year ended 31 March 1986 ($400,630 - 1985). This figure is a representation by management and it has not been audited.

7. Interest-free demand loan

The interest-free demand loan of $265,598 ($265,598 - 1985) represents the cumulative difference to 31 March 1986 between revenues and expenditures that have been advanced by Memorial University of Newfoundland to C-CORE. This amount was fixed by an agreement between Memorial University of Newfoundland and C-CORE dated 12 February 1987 which is effective from 31 March 1986.